

BRITAIN'S WEALTH IN INDUSTRY SERIES

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The Story of **COAL**



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BRITAIN'S WEALTH IN INDUSTRY SERIES

THE STORY OF COAL

COAL has been rightly named "Black Diamonds." This is especially true in Britain today where coalmining is one of our largest industries and where everyone is affected by what happens in the mines.

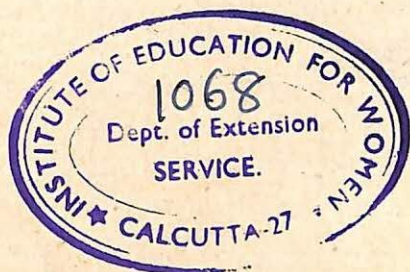
Here, illustrated by splendid photographs and clear explanatory drawings, is the fascinating story of coal, simply yet graphically told. We learn how coal layers and seams have formed over countless centuries from the decayed vegetation of pre-historic forests. We are shown how mines are sunk, drained, ventilated and equipped. We learn too of the various methods of winning the coal and getting it to the surface. We see how it is distributed and the multitude of uses to which it is put in everyday life and industry, such as the manufacture of coal-gas with its bewildering array of valuable by-products.

And from it all there emerges a vivid portrait of the miner himself and a clear picture of the rigours, dangers, and, above all, the true importance of his daily work.

Britain's wealth in industry series

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THE STORY OF COAL



BRITAIN'S WEALTH IN INDUSTRY SERIES

EDITOR'S NOTE

Recent years have seen much greater use made in our schools, and especially in secondary modern schools, of project work. The advantages of this realistic approach in breaking down the artificial barriers which tend to grow between subjects when these are taught in separate and distinct lessons, and in stimulating interest and enthusiasm, are now generally recognized.

This series of booklets is designed to give a clear, accurate and readable account of the processes involved in our main industries. Emphasis has been laid on visual presentation, by photograph, drawing and diagram, and in this way it is hoped that the booklets will serve a specially useful purpose.

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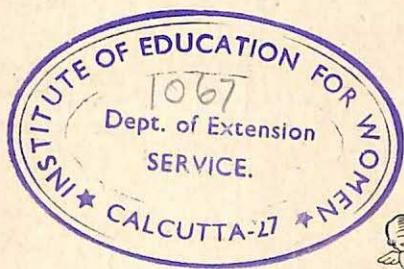
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THE STORY OF COAL

BY HERBERT ARTHUR

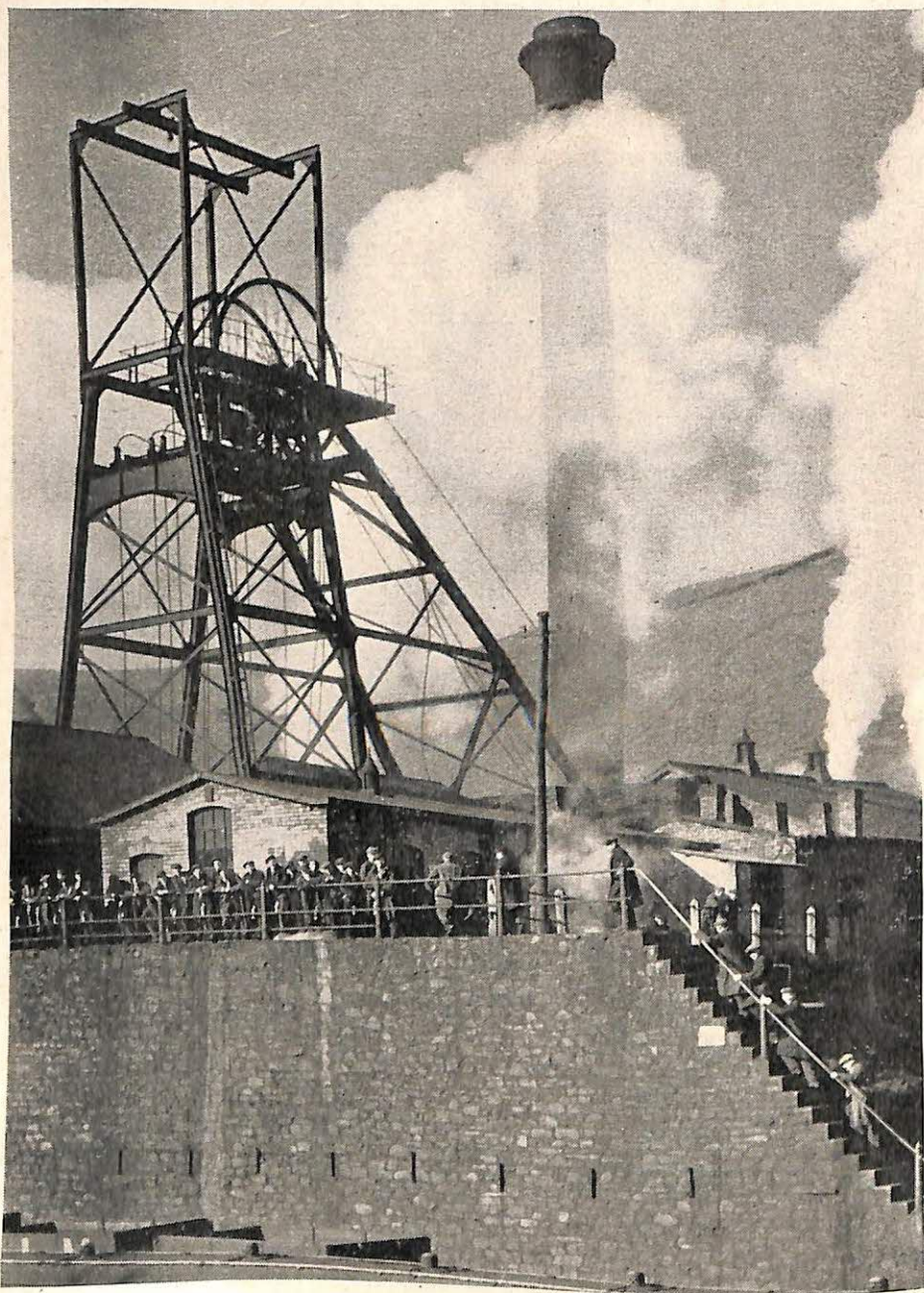
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At the pit-head. This picture of a colliery in the Rhondda Valley, Wales, shows the steel headgear frame dominating the scene. The men returning to the mine for the next shift are waiting at the lamp house.

The Story of COAL

Coal-mining is one of Britain's largest industries, and its well-being is vital to modern life. In this story we consider different aspects of coal : how it is formed, how it is mined, and why it is so important to us.

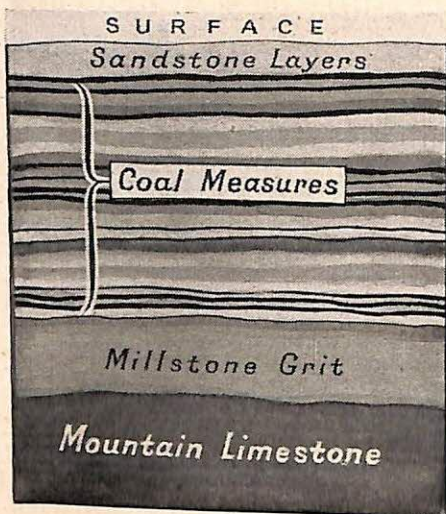
COAL IN OUR EVERYDAY LIFE

WE all take our supply of coal very much for granted, and hardly give a second thought when we see the coal-man tipping sacks of coal into the coal bunker at home. Yet what a story lies behind the delivery of that coal. It is a story that begins in front of a solid wall of coal in a stuffy and dirty atmosphere probably half a mile or so below ground level. This fascinating story involves many kinds of worker and a vast number of different types of machinery and equipment.

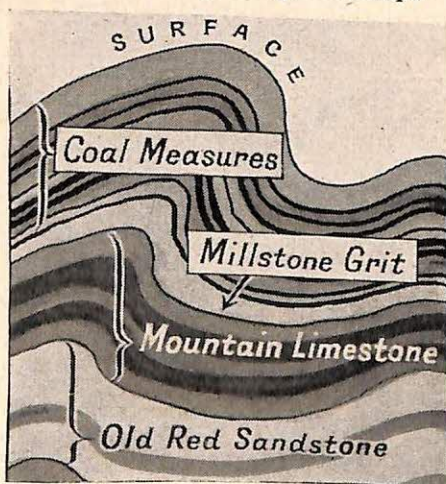
There is little need to emphasize the importance of coal in our modern life. Not only is coal used directly for feeding fires, but it is used in gas-works for producing gas and coke and at power stations in the generation of electricity. You will find it interesting to consider how much coal, coke, gas and electricity enter into our own everyday life. It is because coal is used as a raw material in so many processes that coal-mining is sometimes described as Britain's basic industry.

Anyone who has travelled through a mining district will readily recognize the picture of a pit-head shown opposite. The dominant feature is the tall framework carrying two large wheels, over which

HOW COAL MEASURES TOOK SHAPE

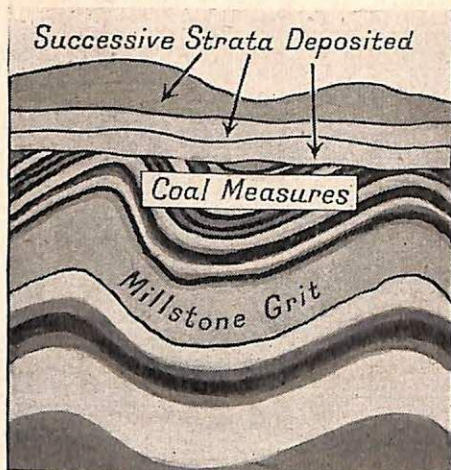


(a) Layers were built up from the vegetation which decayed in great swamps.



(b) After many years the strata became folded as parts of the earth's crust heaved up and others sank down.

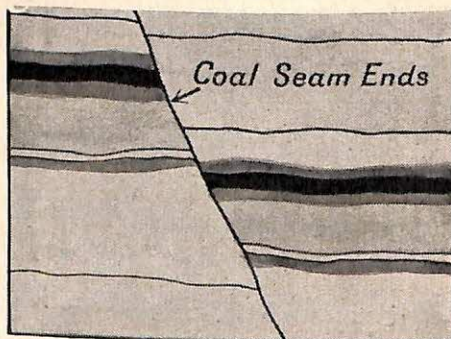
(e) Faults were caused by weakness in the underlying strata, breaking the seam, as shown on the right.



(c) The coal measures were buried by layers of sand, soil or chalk which later became compressed into rock.



(d) The rocks were ground away by the action of glaciers, thus exposing the coal in outcropping seams.



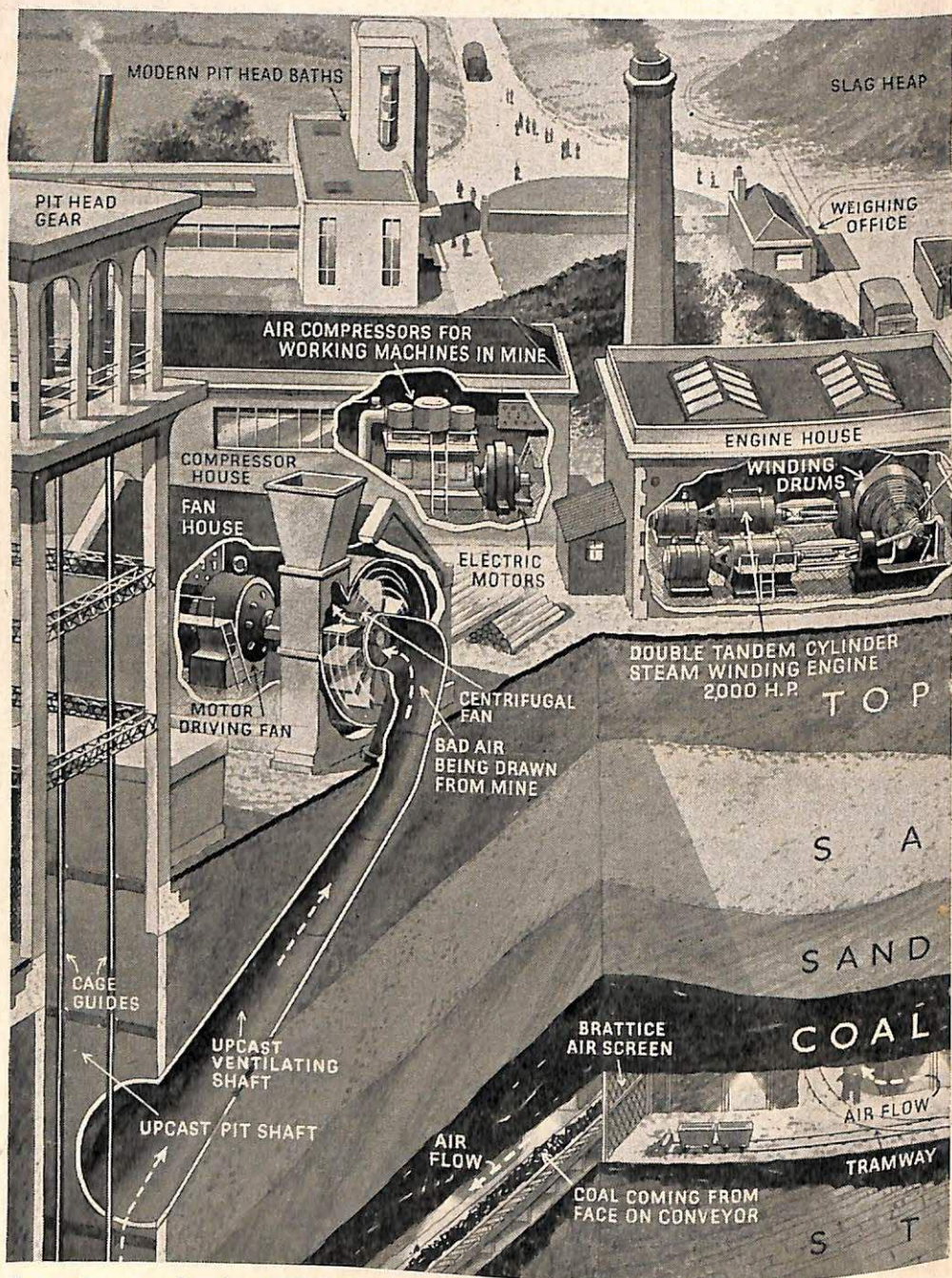
pass wire ropes supporting the lifts or cages which ply up and down between the pit-bottom and the surface. This assembly is called the headgear and is indeed the symbol of a mining community. Let it serve, therefore, as our introduction to this story of coal.

HOW COAL IS FORMED

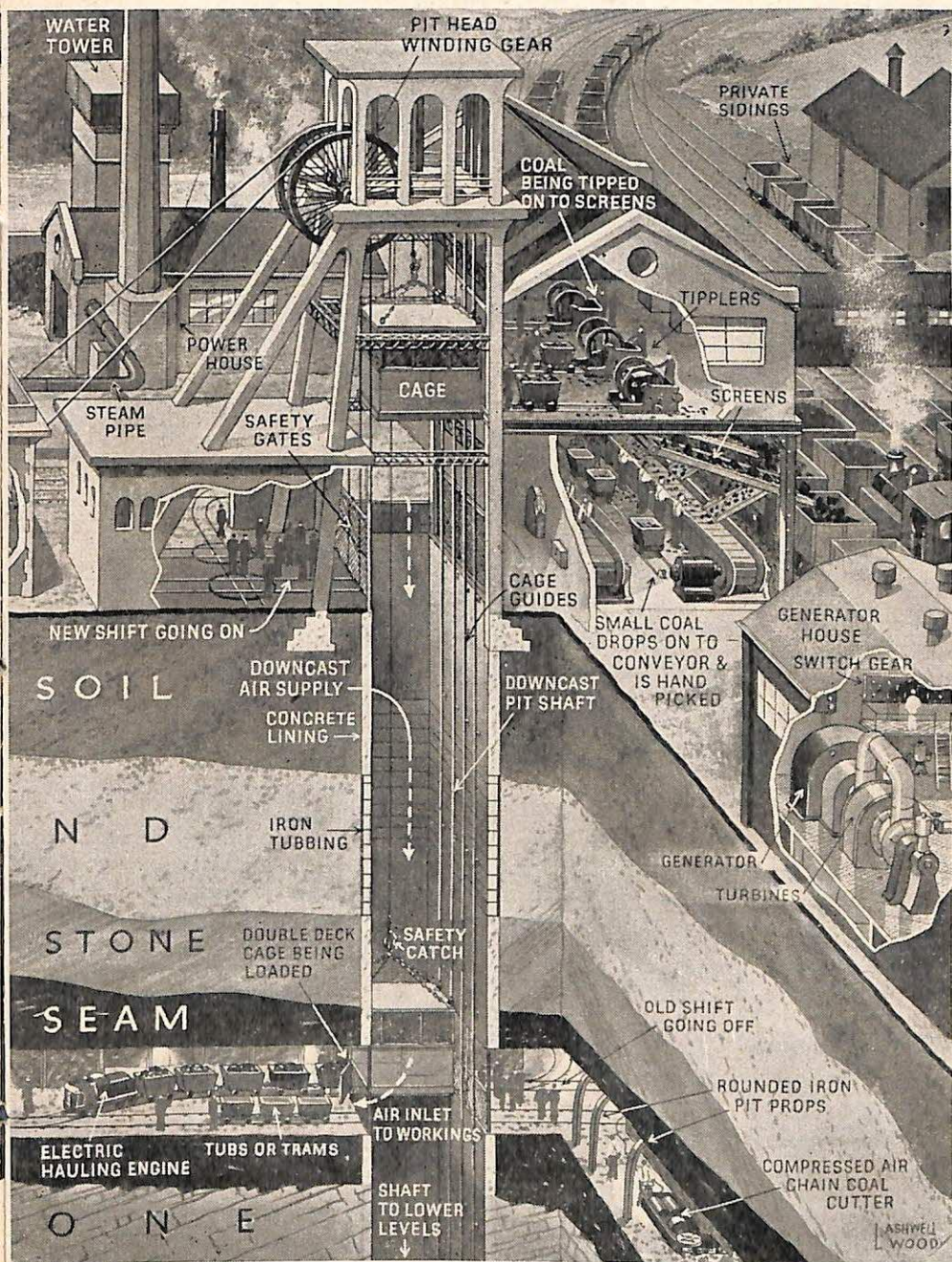
Coal is found in layers or seams of varying thickness and quality and in different positions relative to the earth's surface. The diagrams on the facing page explain how this comes about.

Strange as it may seem, coal is actually formed from decayed vegetation, and illustration (a) shows how layers of decayed vegetation were eventually covered over many thousands of years ago by layers of sand, soil or chalk. Under the terrific pressure of the covering layers these became coal measures and strata of sandstone, millstone grit and mountain limestone rock. Illustration (b) shows how the strata became distorted, and (c) how the top surface was weathered away and then covered over again by further strata; (d) shows that sometimes the coal seams are laid bare, and no doubt coal was first discovered in this way, while (e) indicates how part of the earth's crust can slip and break the strata. The lower coal measures are normally of better quality since they have been subjected to the greater pressure.

Collieries are naturally sited where the coal measures are of good thickness and quality and yet are conveniently near to the surface. Shafts in Great Britain are not normally sunk to a depth of more than 3,000 ft. because of the expense. Even this, however, is over half a mile and can present tremendous engineering problems, particularly if the ground through which the shaft has to be sunk is inclined to be wet. A shaft is normally some 20 ft. across, and a brick or concrete lining is usually made as the sinking of the shaft progresses, but excessive wetness calls first for special treatment. Sometimes the surrounding soil can be drained by sinking in it a large number of perforated pipes, but at greater depths the surrounding strata have to be treated to prevent water from passing through them. Concrete can be pumped into the adjacent strata under pressure, or the water may be frozen



A modern coal-mine. All the parts are here seen in correct relationship to each other as they would appear if the ground were cut away to reveal the various layers



from the top soil down to the coal seam. In this drawing the artist has shown a concrete headgear frame replacing the older type which was made from timber or steel.



Safety check. At the top of the shaft the banksman (*left*) makes sure the miners are not carrying matches or tobacco, checks the working of their lamps, closes the cage gates and signals the winding engineman.

by laying pipes around the shaft and connecting them to a refrigerating plant. As may be expected, such methods add enormously to the expense of sinking the shaft. Through wet sand curved iron plates are used, fastened together by rivets or concrete. This is known as tubbing. When descending a pit-shaft an indication of the strata may be obtained by noting the different linings used.

A VISIT TO A MODERN COAL-MINE

So far we have had one brief glimpse only of a coal-mine: the pit-head. Let us now take a look at all the various parts which go to make up the modern coal-mine. These are clearly shown in the large drawing given on pages 8 and 9. You will notice that we have imagined portions of the walls of the buildings and of the ground cut away so that we can see as much as possible of the machinery and the underground workings. The drawing is largely self-explanatory, but let us consider some of the parts in more detail.

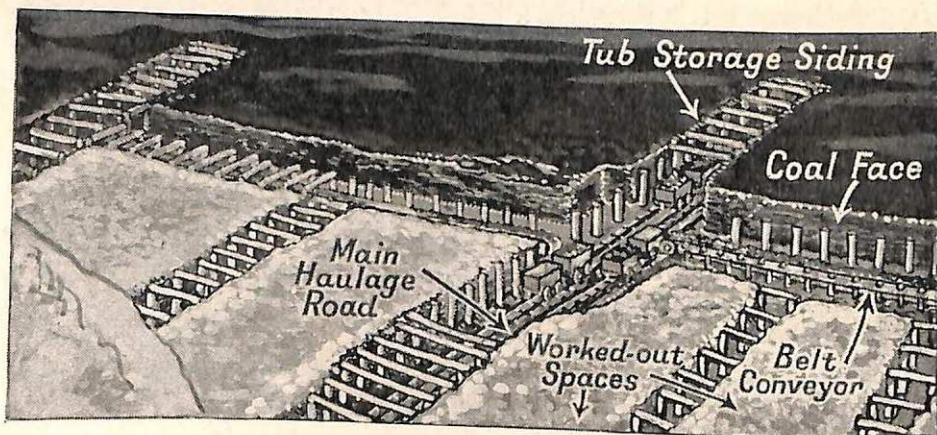
Ventilation and Drainage.—You will notice at once that we have two shafts down to the underground workings. Each shaft is fitted with pit-head winding gear and cages capable of carrying men and equipment. These two shafts serve a most essential purpose—that of forming a ventilation system for the underground workings. Coal seams contain large quantities of gas, chiefly methane, or fire-damp, as it is popularly called, and this is liable to accumulate in any unventilated part of the workings. When mixed with air in certain proportions it readily ignites and can be the cause of disastrous explosions, so it is absolutely essential for the safety of the miners that there should be a continual flow of fresh air through the workings. As there may be several thousand men working down the mine, and it is naturally hot so far below the surface, fresh air is also needed to make their working conditions tolerable.

In the drawing the direction of the air-flow is clearly shown. The fan producing the air-flow is driven by electricity from the generator house. Here the generators are driven by turbines on steam from the boiler house. The generator house also supplies the electricity for other electrical equipment used in the mine.

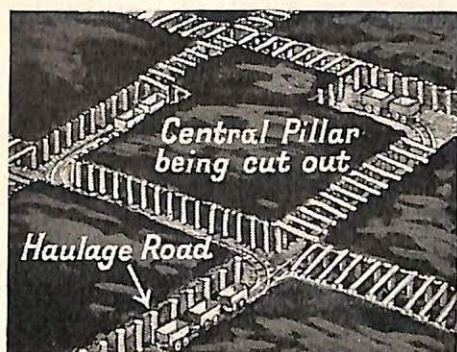
There is usually a more or less straight road connecting the two shaft bottoms and, unless we take special precautions, all the fresh air would pass along this straight road and would not get round the network of side-roads and galleries leading to the coal-face. The air stream is actually deflected through these galleries by means of a system of screens and doors. In our drawing a screen of rough canvas, called a brattice, is shown deflecting the air-flow into a side-road.

Another fundamental problem in a mine is that of getting rid of the water which continually drains into the workings. The normal way of dealing with this is to extend one of the shafts down below the pit-bottom to form a kind of well, and to construct the roads and galleries so that they all slope slightly towards this shaft. All the water will then run into this well, called the sump, and powerful pumps work continuously to raise this water to the surface. It is interesting to note that the weight of water so moved is usually several times greater than the weight of coal obtained from the mine.

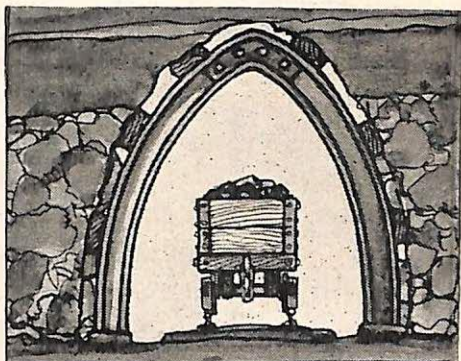
The Journey to the Coal-face.—After collecting their lamps from the lamp house the miners enter the cage to be taken rapidly underground. The picture on page 10 shows them entering the cage.



The longwall method. Longwalling means that the whole width of the seam is worked outwards, leaving a space at the rear which is called the goaf. Strong temporary props of timber or steel must be provided, or the weight of strata above would smash in the roof. Piles of stone rubbish are used for permanent support.



In the pillar-and-stall method roads are cut through the coal, dividing it into blocks or stalls and working round the outer edges towards a central pillar.



A means of securing a permanent road and thereby ensuring safety is to brick up the walls and span the roof with steel girders or by steel arches as shown here.

There are two cages to a shaft, both cages being operated together by the winding engine. As one cage is raised the other descends, thus counterbalancing the load as far as possible. The large wheels carried on the headgear frame are some 20 ft. in diameter and act merely as pulleys to change the direction of the ropes supporting the cages. The winding drum is in the shape of a double cone so that when a cage is at the pit-bottom the rope is wound round the narrow end. This lightens the strain on the winding engine as it starts up. The engine is usually driven by steam from the boiler house, although in new pits electric motors are being used.

As indicated on page 9, the main roads carry a double tram-track and are at least 11 ft. wide. Along any main road it is unusual to find the height less than 5 ft. The walls are built of packed stone several feet thick and strengthened by wood or steel pit-props. These props support roof beams or girders, the latter taking the strain of the rocks and soil above. Steel arches are now often used in place of separate props and girders. Stone dust is liberally sprinkled everywhere. Coal dust makes the atmosphere highly inflammable, but stone dust, which is quite inert, reduces this risk.

The miners travel the major portion of the distance to the



Hewing coal. The picture above shows how coal is won with a pneumatic drill; in some seams this is the most suitable way. In the thin seam shown below a helmeted miner is seen "hand getting" the coal from the coal-face.



coal-face in pit-trucks hauled by an electric locomotive. This is operated by electric battery and is fast replacing the pit pony. The main roads are lit by electric light, using electricity generated above ground.

The branch roads leading to the galleries are normally about 7 ft. wide and carry a single tram-track. Along the roads the brattice air screens and doors regulating the flow of air to all parts of the mine workings can be seen. These doors are double, the force of the air-flow automatically keeping them shut so that a man can open and go through one door at a time without breaking the air stop.

The last part of the journey to the coal-face will probably have to be walked, the distance and degree of comfort depending upon the thickness of the coal seam. It may even be necessary to crawl a short distance to reach the face. Here, far away from the pit-bottom, the air-flow is much feebler and the atmosphere consequently much stuffier.

Methods of Working.—There are two main methods of attacking the coal seam itself. In the longwall method, shown on page 12, the coal-face is worked simultaneously at all points on a wide front. The roof in the rear is supported by stone and waste taken out of the coal-face, using props and girders, or steel arches, to extend the approach roads to the face.

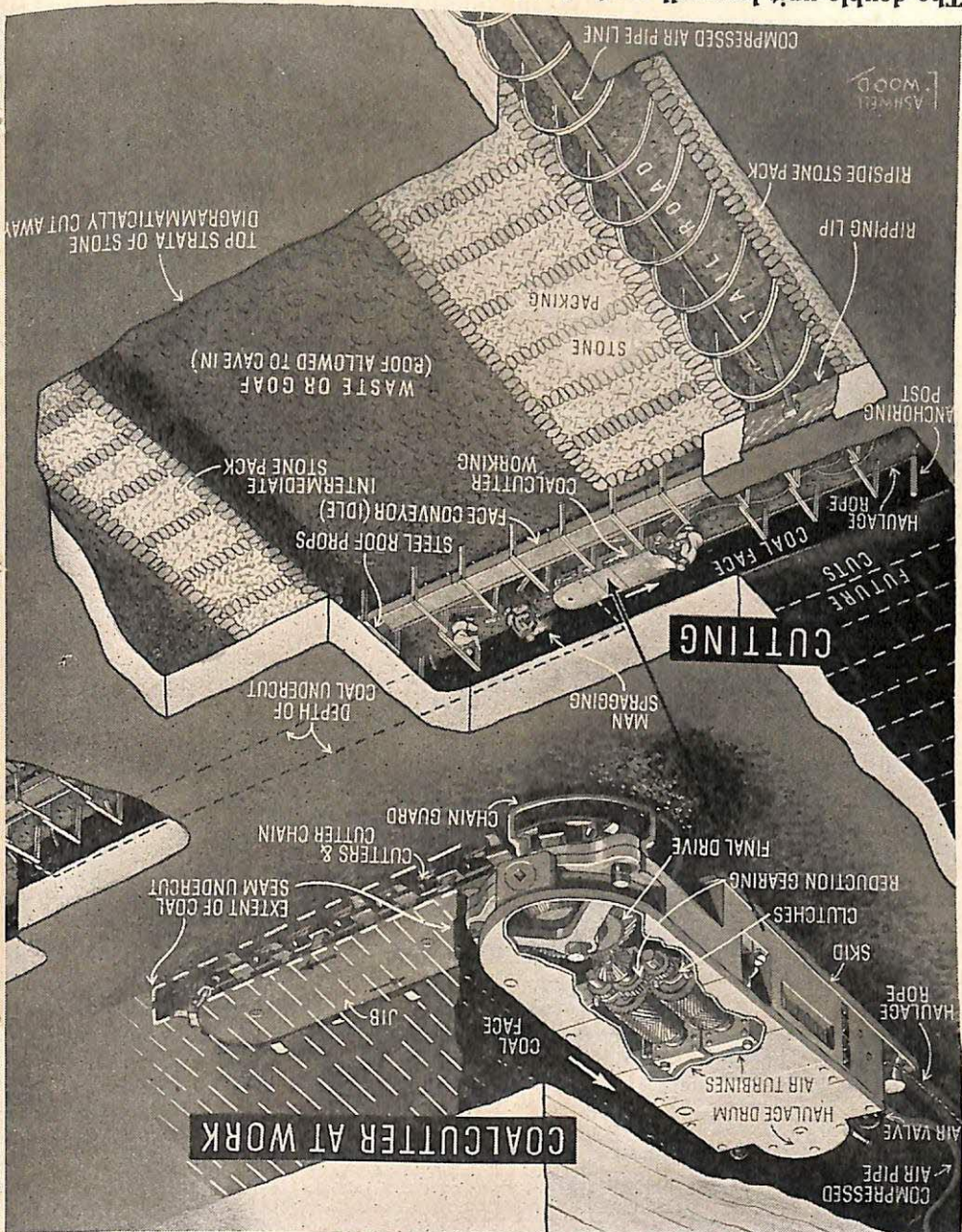
In the pillar-and-stall method, shown on page 13, roads are cut through the coal, so dividing it into a number of blocks or stalls. As the coal is worked from out of these stalls temporary roof support must be provided, but when the stall has been completely cleared the roof is often allowed to collapse and fill up the space.

In either method the miner at the coal-face will probably do his own roof-support work, using either wooden props with a lid to spread the support, or steel props with one end pointed. A wooden prop is shown in the upper picture and a steel prop in the lower picture on the page opposite.

So far we have considered how the pit is made safe and how it is organized to allow the coal-face to be reached. We now come



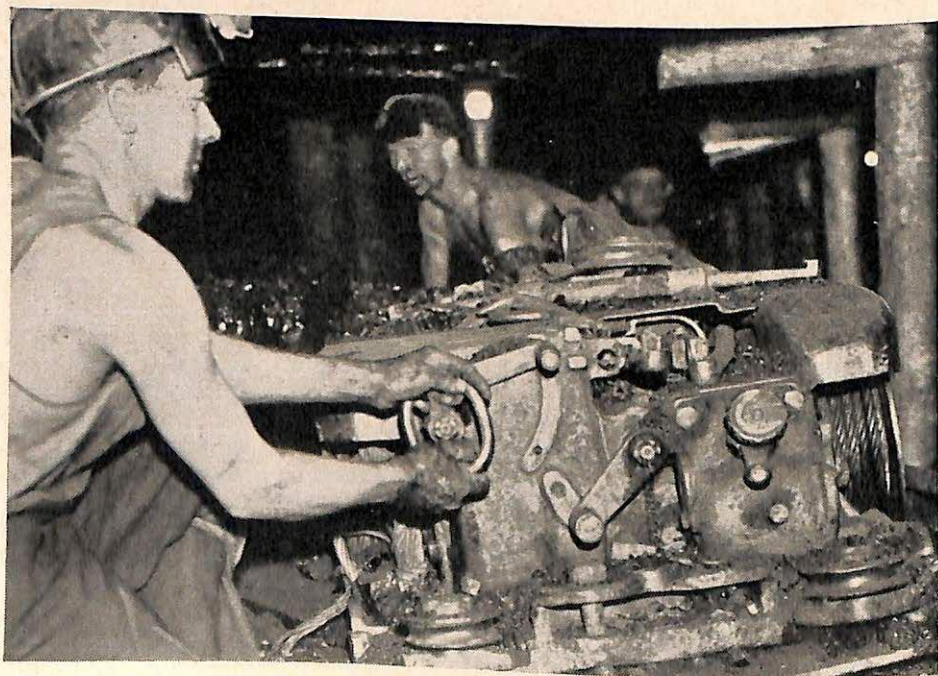
The double-unit longwall method. After the coalcutter (left) has ripped its way through the coal-face the coal is blasted or hewn down, and miners who act as fillers (top centre) shovel the loose coal on to the face conveyor. This automatically transfers it to the gate conveyor. From the conveyor the waiting tubs are loaded for trans-



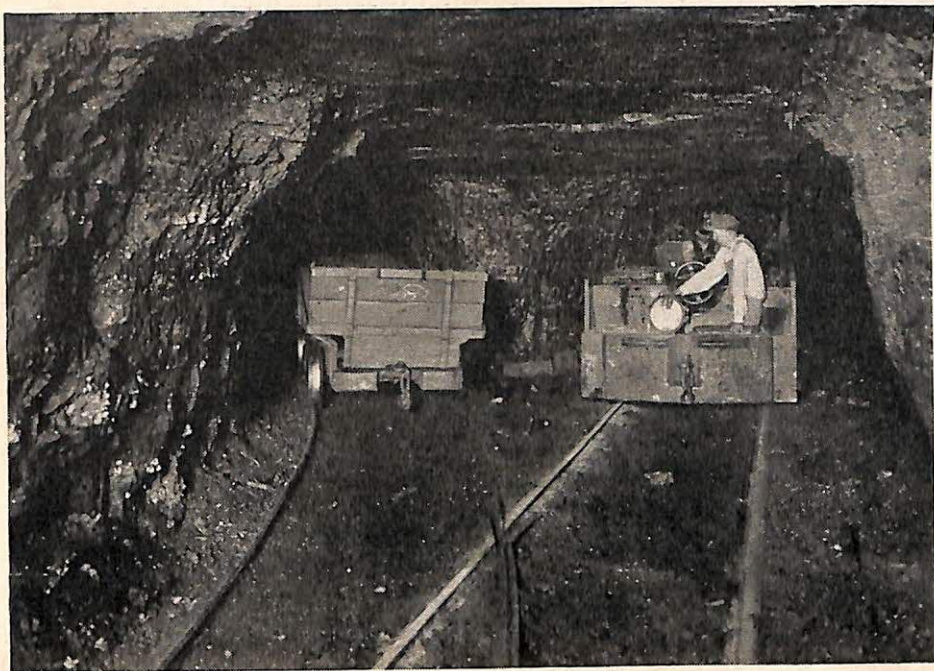
to one of the most interesting parts of our story—how the miners actually win the coal from the coal-face.

Winning the Coal.—The coal-face is first undercut, that is, a deep channel is hewn out of the base of the solid wall of coal. While this is being done, short wooden props called sprags are jammed between the lower part of the coal-face and the ground to prevent the coal-face collapsing before the undercutting is completed. A small charge of explosive is then fired in the coal-face near the roof, and this brings down the whole coal-face as loose coal. Specially trained men called shotfirers arrange and fire the charges of explosive.

The undercutting may be done by miners using picks or compressed-air drills, the tool used depending upon the conditions at the coal-face. The pictures on page 14 show miners using these two tools. In more modern pits, however, the work of undercutting is speeded up by using coalcutters. These are powerful machines



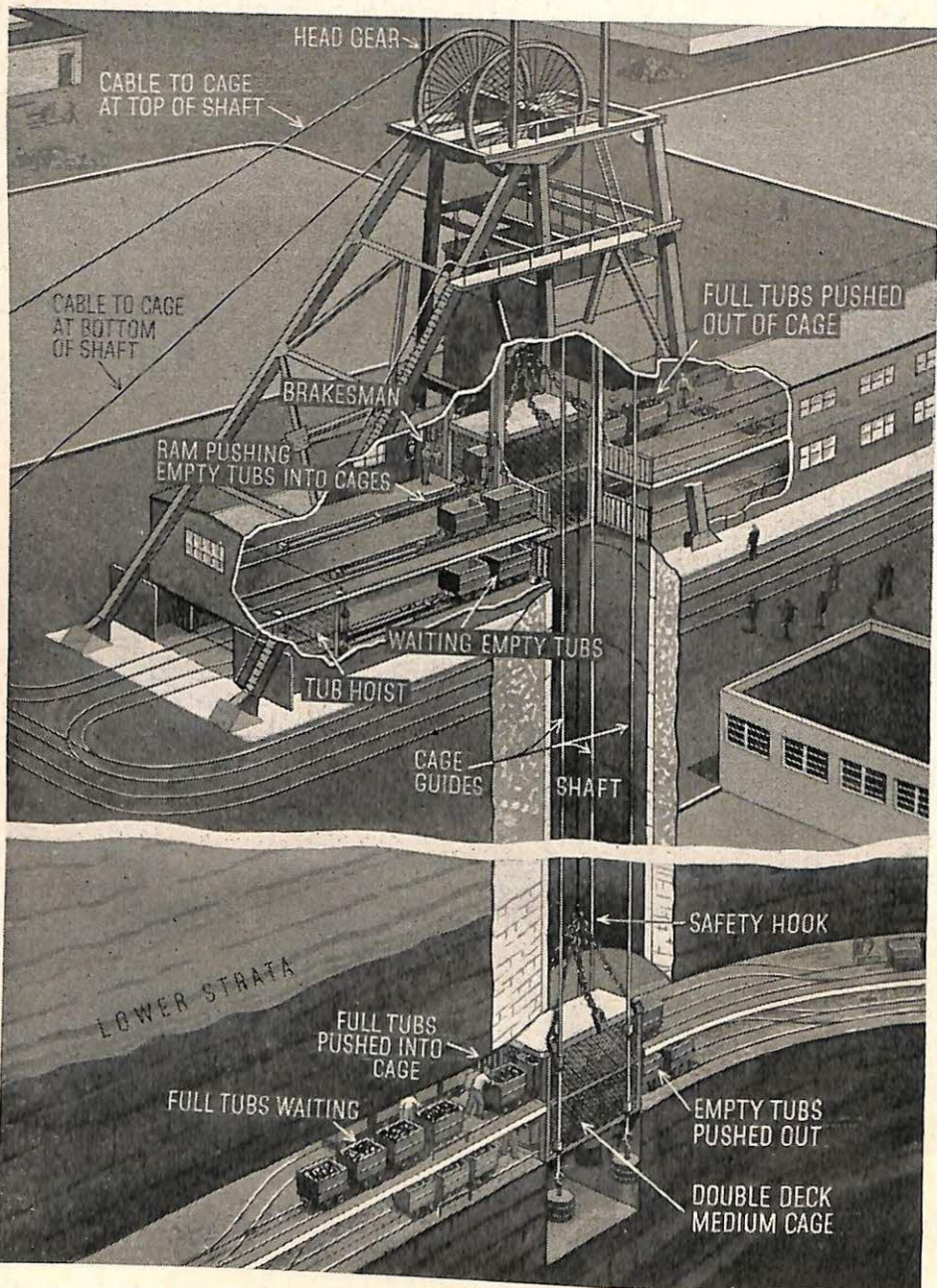
Coalcutter at work. A miner in a Midland colliery working a coalcutter. The method of working and details of the cutter are given on page 16.



Mechanized "pit-pony." Here is shown the type of electric locomotive used to haul trains of loaded pit trucks to the shaft bottom. It supersedes the pit-pony.

and consist essentially of an endless chain, to the links of which strong cutting teeth are fixed, driven by an electric motor or a compressed-air turbine. A compressed-air-driven coalcutter is shown at the top of page 16. By winding in the rope called the haulage rope the machine pulls itself along the coal-face at a speed controlled by the operator of the machine. The cutting chain travels quickly round an arm which projects under the coal seam and cuts a deep channel as the coalcutter moves along the face. On the facing page we see a picture of a miner operating a coalcutter.

The main drawing on pages 16 and 17 shows the complete process known as the double-unit longwall method. In this method the long stretch of coal-face is worked in two sections. The same procedure is used in both sections, but at any one time the two teams of miners in these sections are at different stages. The



Bringing coal to the surface. The tubs filled with coal are brought to the surface and the empty tubs returned to the gate road far below at the bottom of the shaft. The double cage ensures a continuous supply in both directions.

gate road is the dividing line between the two sections and it is along here that the coal is taken away from the entire coal-face. Each section has a tail-road which serves as an approach road for each team of miners and their equipment, and in our drawing this road is shown carrying the necessary services to the coalcutter, in this case a compressed-air pipe line.

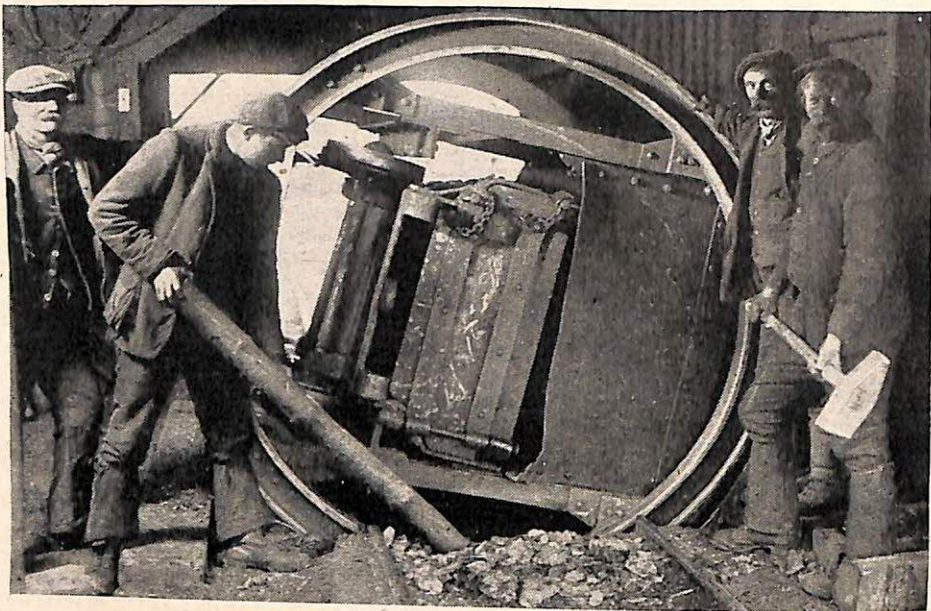
In the drawing the team in the left-hand section are proceeding with the undercutting prior to blowing down the coal-face. The team in the right-hand section have already blown down their coal and are now loading it on to a belt-conveyor running along the coal-face. Where the gate road leads away from the coal-face the coal is transferred on to another conveyor which carries it along and then loads it into the waiting tubs.

The compressed air for the coalcutters is supplied from a air-compressor house on the surface, such as shown on page 8, the air compressors being driven by electric motors. Electric motors are sometimes used directly for operating underground machinery, but elaborate precautions must be taken in their construction to prevent any open sparking from taking place.

Bringing out the Coal.—We have seen how the gate-conveyor brings out the coal from the coal-face and loads it into waiting tubs. The tubs are then taken along the tramways by electric locomotives to the pit-bottom. The picture on page 19 shows one type of locomotive and tub used.

On page 20 we have a drawing illustrating how the double-deck cage is used to maintain a continuous supply of loaded tubs up to the surface and empty tubs down to the pit-bottom.

If we turn back to page 9 we can follow the unloading process. The loaded tubs are run into drum-like structures, called tipplers, and are there inverted. The coal falls on to meshed chutes, called screens, which lead down to waiting railway wagons. The larger pieces of coal pass straight down into the wagons, while the smaller pieces fall through the holes on to other chutes leading on to a conveyor belt. Sometimes the screens are given a shaking motion to sift the coal better. The smaller coal is hand-picked from the



Screening and grading. When the tubs of coal have arrived at the surface they are run out of the cage to the tipplers, shown above, which turn over and deposit the coal on to the shaker screens. These screens, shown below, roughly grade their contents as to size. Dust and small pieces fall through, and the large pieces pass on to be loaded into trucks. The small coal is sorted by hand.



conveyor belt into waiting tubs. Pictures of the tipplers and screens are shown on the facing page.

On the Surface Again.—Having some knowledge of the needs below ground, let us have another look at the surface buildings and pit-head installations. The drawing reproduced overleaf shows us a typical lay-out at a modern colliery.

We notice that the lamp-room and pit entrance are conveniently sited near to the main entrance, while the small diagram in the bottom left-hand corner of the illustration overleaf reminds us of the ventilation system.

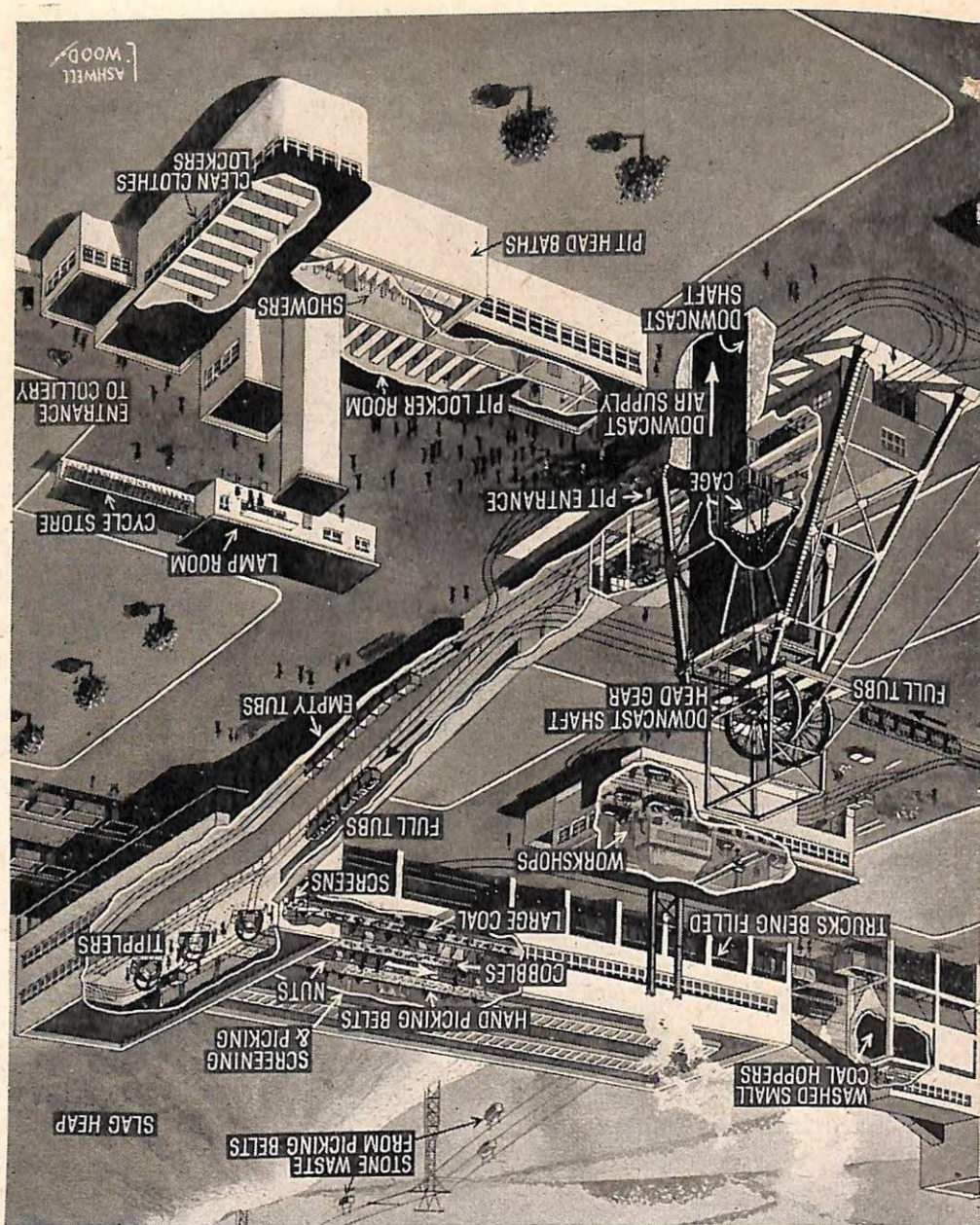
The primary source of energy is some of the coal taken out of the mine; this is consumed in the boiler house and there produces steam. In our first drawing, on pages 8 and 9, we showed the steam working the winding machinery direct, but in the drawing overleaf we show the alternative method of running the winding machinery by electric motors.

A more elaborate system is shown for the handling of the coal on its arrival from below ground. The screening is done in several stages so that we get coal being delivered on conveyor belts and thence into trucks graded into sizes as large coal, cobbles and nuts. The small coal passes to the washing plant, being known as washed small when it finally emerges from the coal-hoppers there. The washing process consists of floating the coal in agitated water, when the stone, having a greater density, sinks.

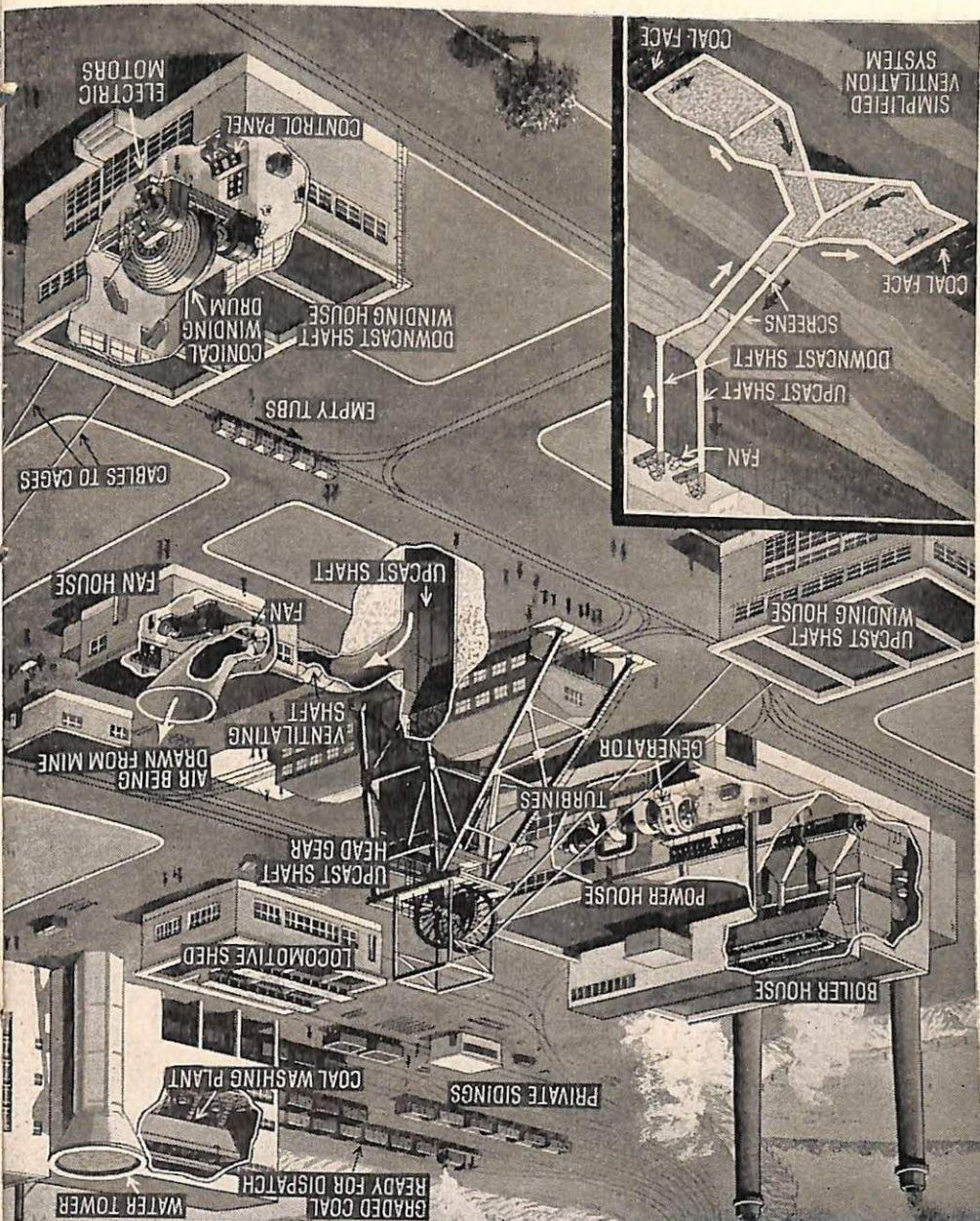
The stone waste, hand-picked from the conveyor belts in the screening and picking sheds and also from the washing plant, is carried away by an overhead railway system and deposited near-by to form the huge slag-heaps which so disfigure the landscape in colliery districts. These scars on the surrounding countryside bear evidence of the ruthless way in which industrial development has been allowed in the past to override all other considerations.

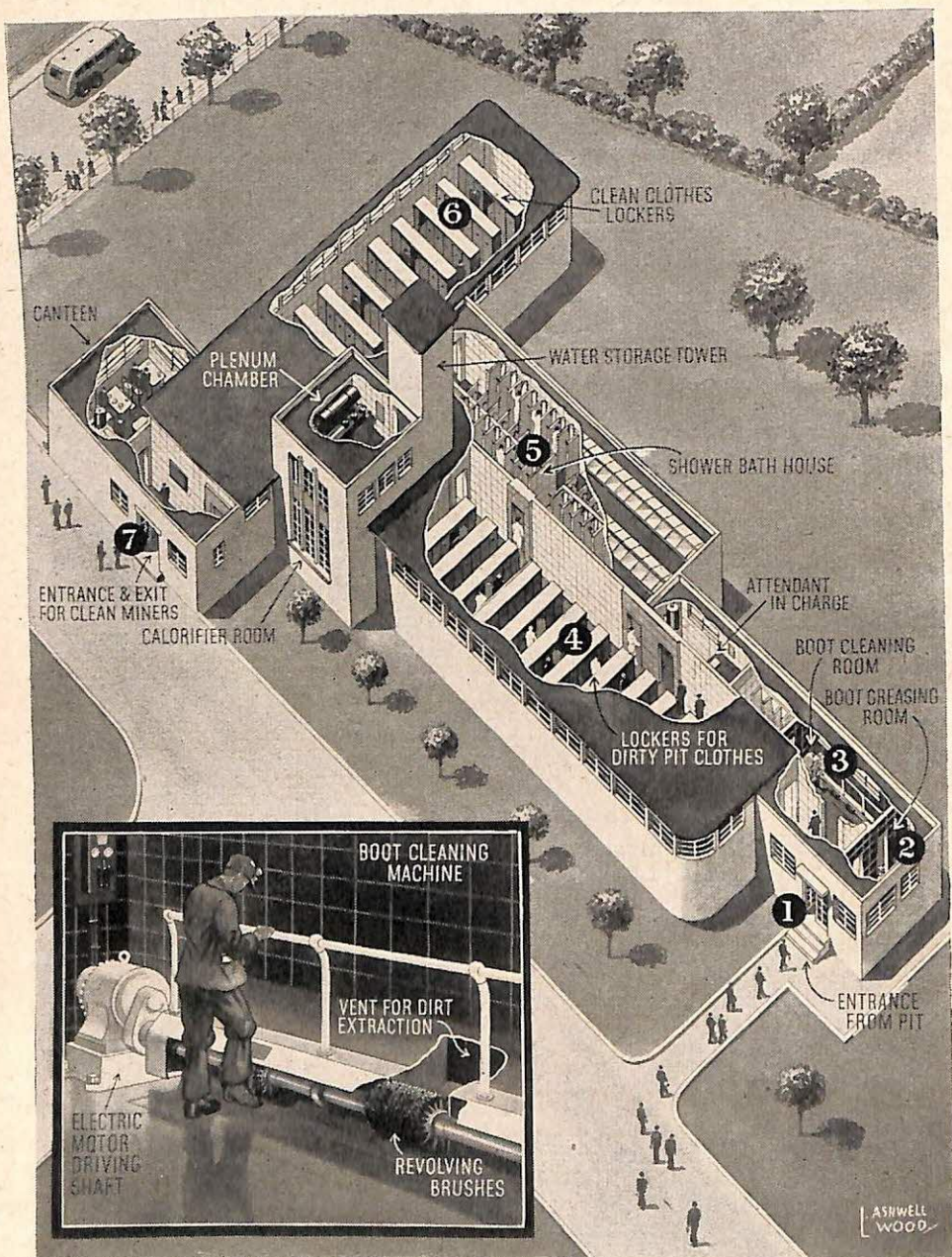
It will be noticed that the tram-tracks for the coal tubs are arranged so that the double-deck cage system can be operated at both the downcast and upcast shafts simultaneously. The paths taken by the full and by the empty tubs are clearly indicated.

at the private siding owned by the colliery. Steam-powered turbines, by generating electricity, provide the immense power needed both for haulage and for the renewal of air in the workings through the use of an extractor fan. The electricity so produced is also used for underground lighting as well as for the charging of accumulators.



Above-ground lay-out. A modern colliery is planned to ensure the minimum waste of time and labour. Pit head baths, locker room and lamp room are within easy access of the pit entrance, while the won coal is brought to the railway wagons in a progressive series of operations. After being graded the coal is washed and loaded





When work is done. At many pit heads the miner has special facilities for bathing and changing into the home-going clothes which, warmed and dried, await him. Automatic devices are available for cleaning boots and a canteen provides welcome refreshment.

Near the main colliery entrance we see the pit head baths and changing rooms. Here the miners change their clothes, into pit clothes if they are coming on duty or into their clean clothes if coming off duty. A more detailed drawing is given opposite, and in this numbers indicate the order in which the tired and dirty miner, straight from the mine workings, passes through the various rooms. The interior of the boot-cleaning room is also shown. The lockers and room are supplied with a steady stream of warm air. This is known as the plenum heating and ventilating system, and the plenum chamber housing the necessary plant is shown in our drawing.

The miner can now travel to and from his work as neatly dressed as any other worker. This is an instance of the greatly improved facilities enjoyed by the modern miner.

TECHNICAL DEVELOPMENTS

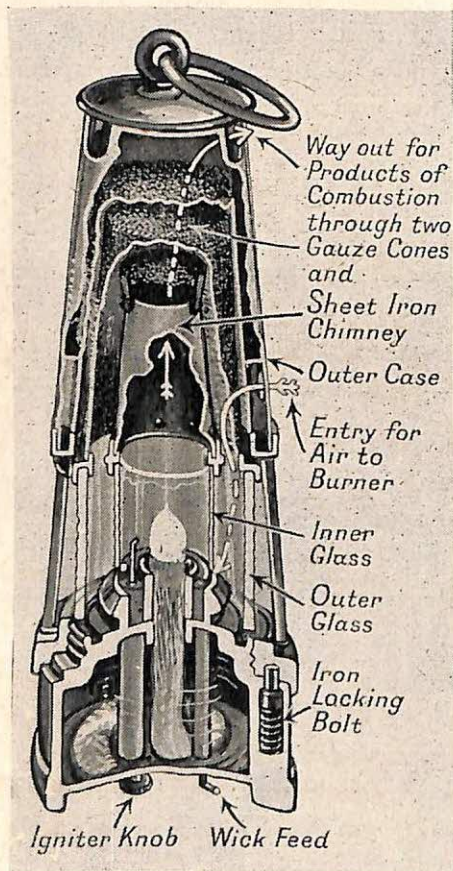
In our story so far we have concentrated on describing the various parts of a colliery and explaining how the coal is obtained. There are other aspects of the coal industry, however, which are of great importance, and a few of these are mentioned below.

Safety in Mines.—Mining is essentially a dangerous job, and every precaution must be taken to avoid accidents. In addition to the precautions we have already described, trained officials called deputies are appointed specially to patrol the workings and find out the sources of any possible trouble. They look for weak patches in the roof, pockets of foul air and faulty roof-support work, and also see that the miners themselves are carrying out all the safety regulations which must be rigidly enforced when many lives are at stake.

Technical Developments.—As well as ensuring that all the machinery and equipment in our coal-mines is kept in good working order and is used properly, we are also interested in making improvements. It is of vital importance that we should obtain coal as quickly as possible from our coal-mines, and any development which will speed up the work at any one of its various stages or increase safety in the mines will have this desired effect.

Electric underground locomotives, conveyor belts and mechanical coalcutters are examples of the first type of technical development, while instruments for detecting and measuring the concentration of foul gas and the safety lamp are examples of the second type.

Many scientists are engaged on this work of inventing and perfecting new types of mining machinery and equipment, and improving existing types. The accompanying illustrations show how the miner's safety lamp has progressed from the original Davy lamp consisting simply of a naked light enclosed by an iron gauze.

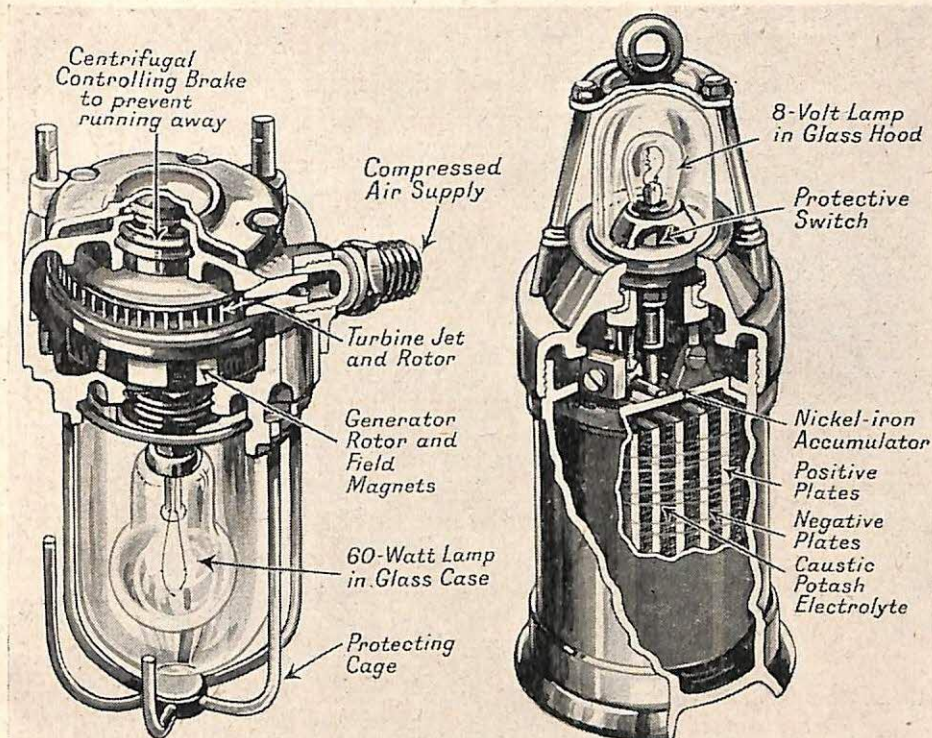


A modern miner's safety lamp made on the original Davy principle. Flame is unable to pass through the gauze and thus while dangerous gases burn inside the lamp, and are rendered harmless, the foul air outside is not ignited.

PRODUCTS FROM COAL

We began our story by pointing out the importance of coal. Its heating value may be utilized by burning coal in a domestic fire or in a boiler producing hot water or steam. The steam so produced may be used for heating a building or for driving machinery such as the steam engine or the steam turbine used in the generation of electricity. We also mentioned other sources of energy, gas and coke, which are obtained from coal. These are called products from coal because they actually come from the coal itself.

At the gas-works the coal is heated in a special type of oven in the absence of air, a process called distillation, and gas mixed with other vapours is given off. A large part of the plant at the

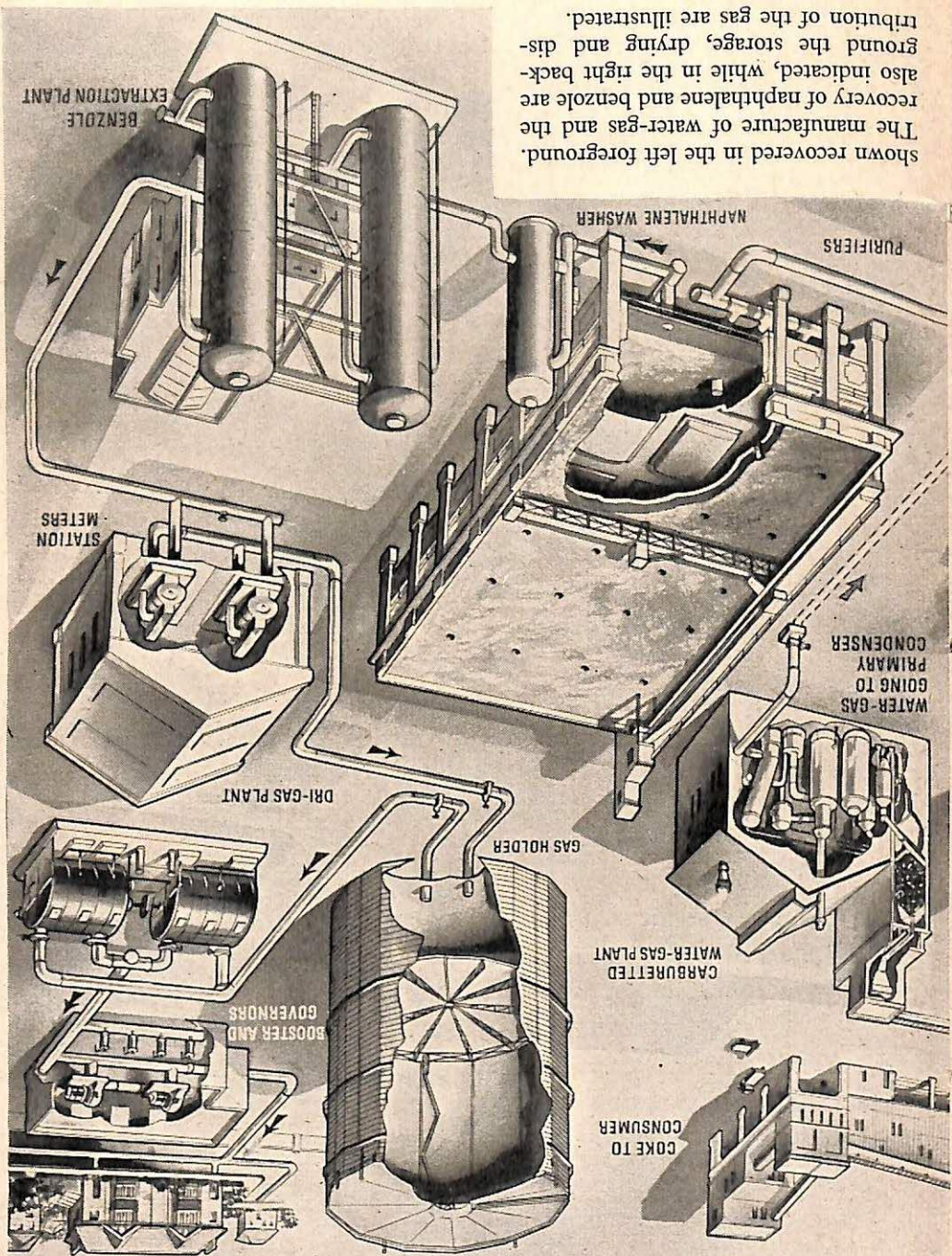


Electric safety lamps. That shown on the left generates its own alternating-current supply, only requiring compressed air to work its compact and self-contained turbine, which runs at 6,000 revolutions per minute. A nickel-iron type of accumulator provides current for the lamp on the right. Both lamps have automatic cut-out switches which operate immediately in the event of the glass heads being broken.

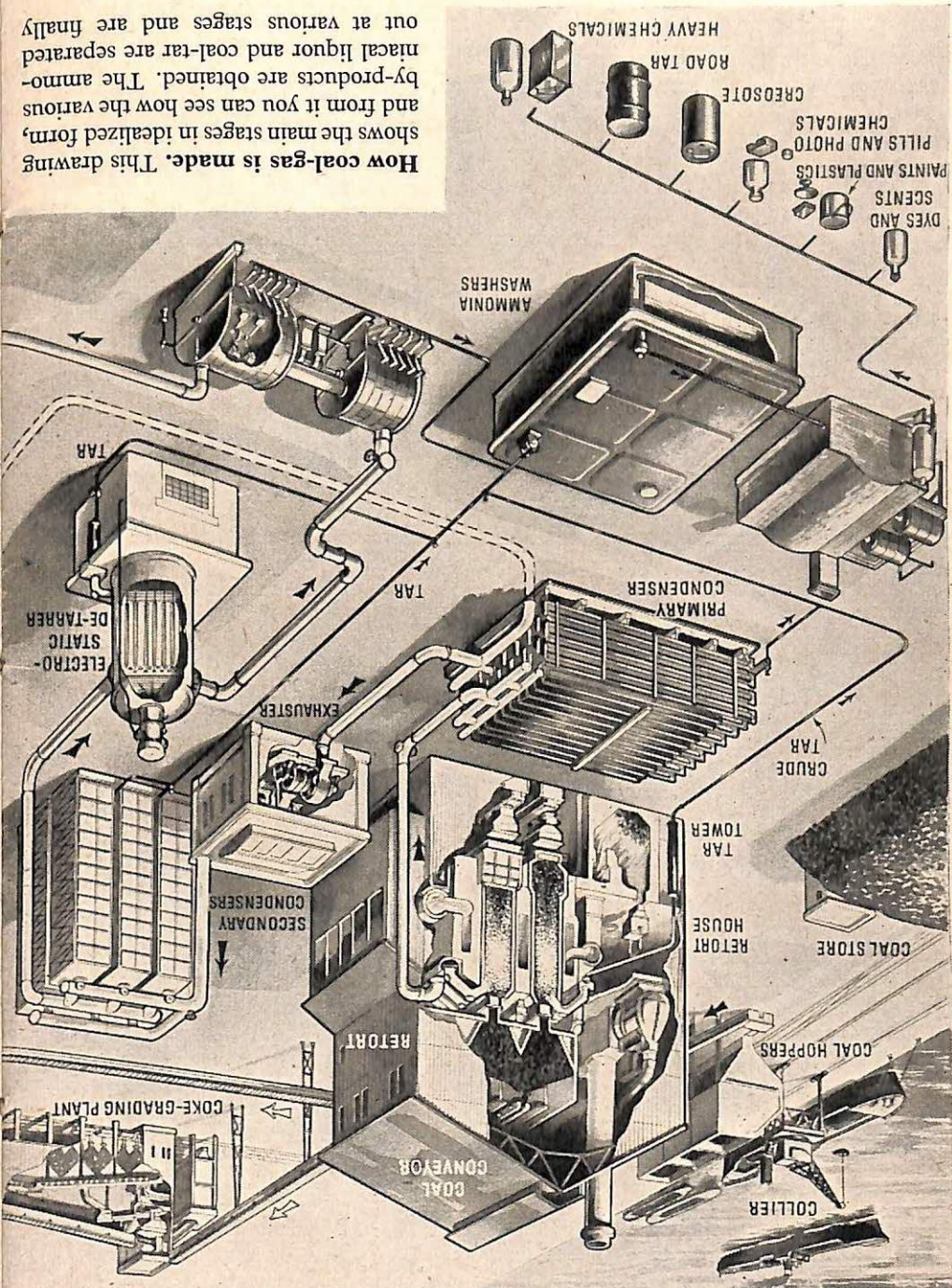
gas-works is concerned with the removal of these other vapours from the gas. Coke is what remains when the gas and vapours have been driven out of the coal. Since the manufacture of gas is the primary consideration at the gas-works, the coke and other substances are called by-products, but they are all products from coal—and important products at that.

Coke is well known as another kind of fuel, but it is also used extensively for other purposes. In the gas-works, steam is passed over some of the hot coke from the ovens and this produces water-gas, which in turn is used in the manufacture of many other important substances. Coke is also employed in obtaining metals from their

The manufacture of water-gas and the recovery of naphthalene and benzole are also indicated, while in the right background the storage, drying and distribution of the gas are illustrated.



How coal-gas is made. This drawing shows the main stages in idealized form, and from it you can see how the various by-products are obtained. The ammonia-liquor and coal-tar are separated out at various stages and are finally



ores, and is one of the raw materials used in our great iron and steel industry.

From the purification of the gas we obtain two liquids, ammoniacal liquor and coal-tar. From the ammoniacal liquor valuable fertilizers, such as ammonium nitrate and ammonium sulphate, are manufactured. Coal-tar contains many important substances, such as benzene, toluene and carbolic acid, as well as many other substances from which further chemicals of great importance in modern life can be obtained. These chemicals are used in the manufacture of products such as dyestuffs, medicines, disinfectants, perfumes, flavourings, cosmetics, explosives, varnishes and lacquers. It is not too much to say that practically every industry and art in Great Britain depends to some extent upon substances made from coal-tar.

Other important by-products of coal-gas manufacture are naphthalene and benzole. The drawing on the two preceding pages should enable you to follow the main stages in the production and purification of the gas.

Perhaps you now realize in greater measure the vital contribution that the coal-mining industry makes to our modern way of life.

SUGGESTIONS FOR FURTHER READING

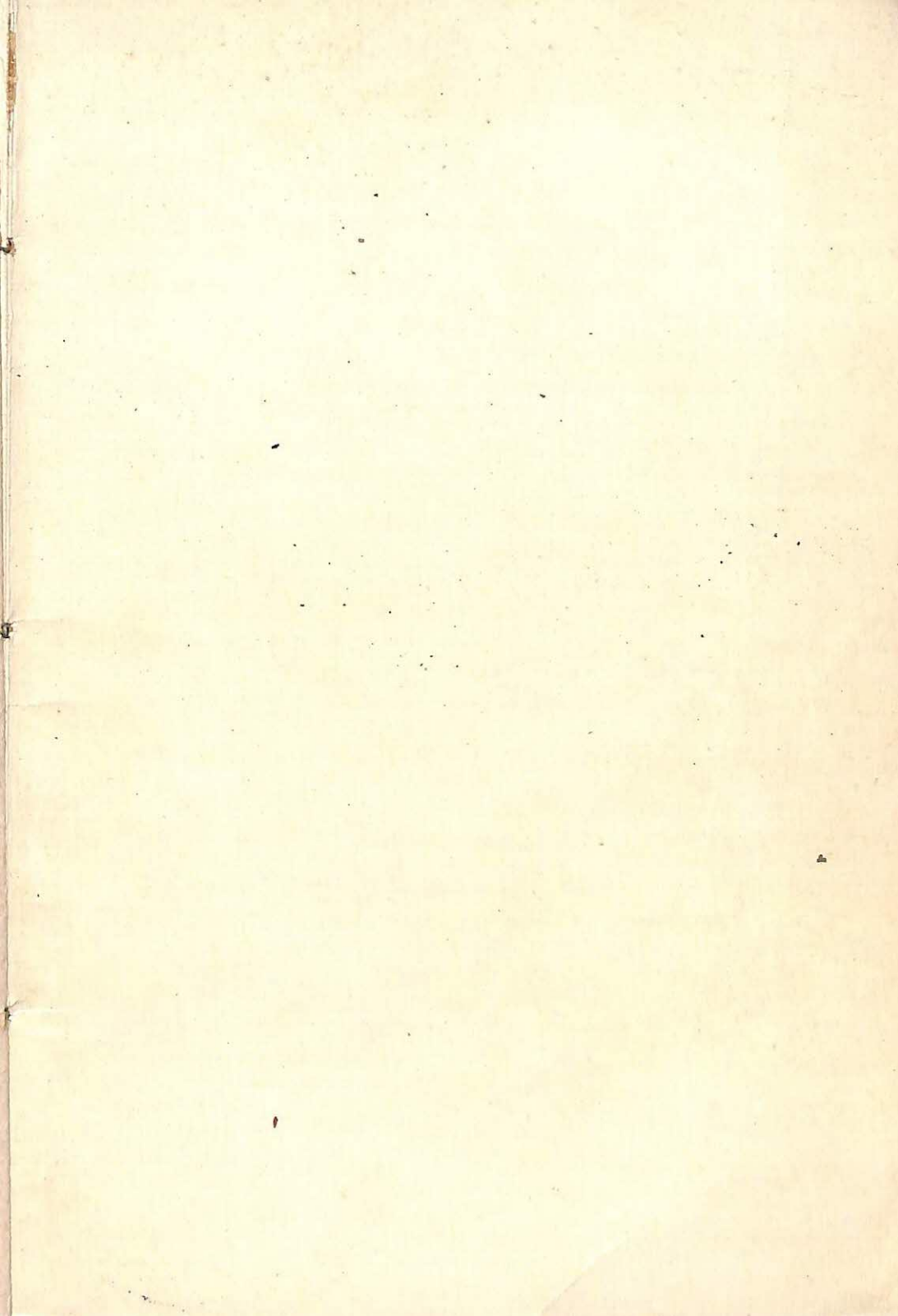
In this compact little book many important matters have been but briefly mentioned. You may be interested to know more about some of them, and suggestions for further reading are given below.

Two books which will tell you more about the formation of the strata which constitute the earth's crust are *Geology for Beginners*, by W. W. Watts, and *Solving Earth's Mysteries*, by H. H. Swinnerton.

On the other hand, *Kingsway Social Geographies—Book 4, Miners and Manufacturers*, by P. R. Rayner, and *History of the Basic Trades—Book 1, Coal, Iron and Steel*, by H. Kay, explain the growth of mining and other industries.

A couple of interesting books which outline the important ways in which scientists have influenced the development of our main industries are *Miracles of Invention and Discovery*, and *Science in Industry*, by A. M. Low.





THIS series of booklets is designed to give young people a clear insight into the essential processes involved in our main industries. Each has 32 pages, and about half of the total page area is devoted to large, lettered wash-drawings and photographs.

The books are written and arranged by Herbert Arthur, who, with his wide experience in teaching, technical development work and educational administration, is able to present facts accurately and clearly, and in such a way as to stimulate interest and encourage further study. Every young person will enjoy and benefit by these splendid books.

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